AFOSR - ~~Grant Number~~ : 80 - 0082

Seismic Crustal and Subcrustal Phases Propagation

ATTENUATION OF LOCAL PHASES IN WESTERN EUROPE

1

by

M. Bouchon*, B. Massinon**, P. Mechler***, M. Nicolas***

31

* Laboratoire de Géophysique Interne
Université Scientifique et Médicale de Grenoble
BP 53 X, 38041 Grenoble, France

** Laboratoire de Détection et de Géophysique
Commissariat à l'Energie Atomique
BP 136, 92124 Montrouge Cedex, France

*** Laboratoire de Géophysique Appliquée
Université Paris VI
T. 15 - E. 2
4, Place Jussieu, 75230 Paris Cedex 5, France

October 1981

Annual [redacted] Scientific Report, 1 December 1980 - 30 September 1981

Approved for public release; distribution unlimited

Prepared for :

ADVANCED RESEARCH PROJECTS AGENCY (DOD)
AFSOR, BOLLING AIR FORCE BASE, DC 20332 - U.S.A.

and

EUROPEAN OFFICE AEROSPACE RESEARCH AND DEVELOPMENT
LONDON - ENGLAND

Grant Number : 80 - 0082

ATTENUATION OF LOCAL PHASES IN WESTERN EUROP

by

M. Bouchon*, B. Massinon**, P. Mechler***, M. Nicolas***

* Laboratoire de Géophysique Interne
Université Scientifique et Médicale de Grenoble
BP 53 X, 38041 Grenoble, France

** Laboratoire de Détection et de Géophysique
Commissariat à l'Energie Atomique
BP 136, 92124 Montrouge Cedex, France

*** Laboratoire de Géophysique Appliquée
Université Paris VI
T. 15 - E. 2
4, Place Jussieu, 75230 Paris Cedex 5, France

October 1981

ANNUAL
[redacted] Scientific Report, 1 December 1980 - 30 September 1981

Approved for public release ; distribution unlimited

Prepared for :

ADVANCED RESEARCH PROJECTS AGENCY (DOD)
AFSOR, BOLLING AIR FORCE BASE, DC 20332 - U.S.A.

and

EUROPEAN OFFICE AEROSPACE RESEARCH AND DEVELOPMENT
LONDON - ENGLAND

SUMMARY

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the U.S. Government.

Introduction

The propagation of regional seismic waves has been intensively studied in different parts of the world, especially in North America and Eurasia.

Taking the advantage of a dense and homogeneous seismic network set up in France, it is possible to study in detail that propagation of crustal and sub-crustal waves, by selecting different local earthquakes well recorded on this network.

Attenuation versus distance is particularly studied and results obtained on guided waves Lg compared with results on U S and U S S R structures of propagation. Q factors are also computed versus frequency.

On the other hand, an attempt to interprete that attenuation in terms of tectonics differences is proposed.

Seismic Data - Earthquakes

25 short-period stations (Z component) belonging to the L. D. G. seismic network have been selected for this study (Figure 1). The data are recorded on magnetic tape at a rate of 50 samples per second and magnifications are generally 125k and 350k at 1 Hz.

The seismometer has a natural frequency of 1 Hz, and the frequency response of the system ranges from 0.5 Hz to 20 Hz (Figure 2).

Earthquakes have been selected in order to study the propagation of local waves through and below the crust in France, along different azimuths of reception. We have choosen six earthquakes with a local magnitude around $M_L = 4$ (Table I : list of earthquakes) located in or around France.

Localizations made with the L. D. G. network are given with an accuracy of 5 km or less for events inside France and up to 10 to 20 km for the other ones. When possible depths have been computed. They are all shallow but only three of them (West Brittany, Mulhouse and St Pourçain sur Sioule) could be evaluated with a reasonable accuracy ($\pm$ 5 km)

Azimuths of propagation from epicenters to stations are shown in Figure 3.
The location of the earthquakes is as follows :

W. B.	:	West Brittany	on the continental plateau
O	:	Oviedo	in the North-West part of Spain
B	:	Barcelona	in Spain
U	:	Ugine	in the Alps
M	:	Mulhouse	in the South part of the Rhinegraben

Figure 4 gives a representative example of recorded data and anomalies between different travel paths. The event considered is the Barcelona earthquake of 12.14.1980 ($M_L = 3.9$).

Stations LFF and LMR which are located at the same distance from the epicenter $\Delta = 370$ km, record roughly the same Pn and Sn amplitudes (LMR magnification is 4 times the one of LFF). On the contrary, there is no apparent Pg an Lg waves recorded at the LMR station, even though, large amplitude Pg and Lg waves are present at LFF. An explanation for this anomaly is that the path from the epicenter to LMR is oceanic while the path to LFF is continental. The TCF station located 500 km away from the epicenter receives successively Pn, Pg, Sn and Lg with amplitudes about one fourth those at LFF.

Attenuation of Crustal and Subcrustal Phases

a) Global attenuation cœfficient

Let us define A as the maximum amplitude of the considered phase (broad band) within the first few seconds after the onset time

D	:	distance epicenter - station
γ	:	global attenuation cœfficient
A_0	:	constant

$$A = A_0 D^{-\alpha}$$

./.

By measuring A for each station, at Dkm from the source, it is possible to compute γ by least squares method.
Applied on the data described above the principal results are the following :

- the Pn phases is not fairly well observed below 500 km in most of the cases ; its global attenuation cœfficient γ is of the order of 2 and the rather small dispersion accompanying this result means that Pn should not be too much affected by crustal anomalies.
- a similar attenuation figure is found out for the Sn phase, but as it arrives in the P coda, its presence is not always clearly detected.
- Pg and Lg phases when present are strongly energetic in the range of distances of propagation involved : 1 to 10°. The Barcelona earthquake has clearly shown a lack of these phases for oceanic propagation path. Other data show that Lg and Pg do not propagate along paths between France and Corsica.

Five earthquakes among the six previously listed are giving sufficient data to draw amplitudes variations versus distance, after a magnitude normalization at $M_L = 4.0$.
A global attenuation factor γ around 2.3 is given for Pg (Figure 5) and a global attenuation factor γ around 2.5 for Lg (Figure 6).
At distances within 100 km, the observed non linearity of these two attenuation curves is due essentially to the frequency band pass of recorded data.
For both phases, a large scatter between earthquakes observations involves important influence of azimuth, which can be interpreted in terms of crustal anomalies. Nevertheless, according to the rather small amount of events selected here, all the suspected anomalies have probably not been taken into account. It has been observed that propagation paths through the Rhone Valley in France or the Ivrea Zone in Italy were associated with weak Pg and Lg wave's amplitudes at the receiver (both zones correspond to a thin crust area) although Pn and Sn waves are clearly seen even at large epicentral distances (West Brittany recorded in France).

Lg/Pg ratio presents large variations, between 1 to 10, with a mean value around 3 or 4 (Figure 7). No correlation with distance is clearly seen.

These results are to be compared with those obtained by Pomeroy (1978) which show that in the Western portion of the USSR Lg amplitudes are almost equal to P amplitudes while in Eastern North America Lg phases are approximately 5 to 10 times greater than P; or with results obtained by Nuttli (1973) who observed Lg/Pg ratio of the order of 1 to 5 in Western USSR.

γ evaluations have been obtained by measuring the maximum amplitudes of each phase on broad band seismograms. Every frequency however does not attenuate in the same way as it is clearly shown Figure 8 and Figure 9 for the Mulhouse earthquake (July 16, 1980). After narrow band filtering the records from 0.5 to 16 Hz, one can notice a shift of amplitudes from high (8-16 Hz) to low frequencies (0.5-0.75 Hz) when the epicentral distance increases from 295 km (SSF station) to 518 km (RJF station). Amplitudes between Figure 9 and Figure 8 are in the ratio of 1 to 4.

Consequently, it seems necessary to analyse this attenuation for each frequency band. Such an analysis shows an increase of γ with frequency as is shown for example in Figure 10 for Lg waves generated by the West Brittany earthquake. However, γ takes into account both attenuation due to geometrical spreading and inelastic attenuation depending on frequency.

A separation between the two effects is now necessary.

b) <u>Anelastic attenuation for Lg waves</u>

For a uniform point source of elastic waves in a spherical earth model, the amplitudes of dispersed surface waves measured in the time domain are given by :

$$A = A_0 \, (D \sin D)^{-\alpha} \, e^{-KD}$$

where A_0 is a factor independant of distance ; $D^{-\alpha}$ accounts for loss of amplitude due to dispersion ; $\sin^{-\alpha} D$ accounts for loss of amplitude due to geometrical spreading, and e^{-KD} describes the loss of amplitude due to anelastic absorption ; α is $\frac{1}{2}$ for waves different from the Airy phases (Ewing, 1957).

K coefficient of anelastic attenuation is expressed by :

$$K = \frac{\pi f}{Q V}$$

with f frequency of the wave, Q quality factor, V group velocity. In order to show the frequency dependence of this anelastic coefficient K, we have represented for one earthquake West Brittany, amplitudes A (velocities) as a fonction of epicentral distances in three consecutive band pass : 4 - 8 Hz ; 2 - 4 Hz ; 1 - 2 Hz.

Different attenuation coefficients α have been used to fit an attenuation curve to the observed values. Going from $\alpha = 0$ which corresponds to the absence of attenuation due to geometrical spreading to $\alpha = 0.5$ or $\alpha = 1$ wich are more realistic values, and finally to linear attenuation ($Q = \infty$, that is without anelastic attenuation), there is no apparent and clear difference in the quality of the fit. All attenuation curves, however, show a strong dependency between slope and frequency : as the frequency increases, the attenuation curve steepons (Figure 10). Values of K for Lg waves at a period of 1 second have been computed for each one of the 6 earthquakes, except the Oviedo event (N-W part of Spain) for which no Lg waves are recorded in France (Table II).

The cœfficients of anelastic attenuation K are rather different from one earthquake to another.

The mean value for K is :

$$\overline{K} = 0.2 \pm 0.1\, d^{\circ\,-1}$$

which can be compared with Nuttli's results also obtained for 1 second Lg waves and concerning regions at the same scale : the Eastern US ($00.7\, d^{\circ\,-1}$), the Northern USSR ($0.15\, d^{\circ\,-1}$) and the South of the Caspian Sea ($0.35\, d^{\circ\,-1}$).

./.

The attenuation figure for France is comparable to the one obtained for the USSR with a dispersion large enough to let K values reach the values obtained for the Eastern US (low attenuation) and the Caspian Sea (high attenuation).

Another order of comparaison can be the Western US (California) where Richter (1935) obtained $0.6 d^{\circ -1}$.

Concerning the rather large difference between low K values for West Brittany ($0.16 d^{\circ -1}$), Ugine ($0.09 d^{\circ -1}$), Mulhouse ($0.15 d^{\circ -1}$) and high K values for Barcelona ($0.29 d^{\circ -1}$) and St Pourçain sur Sioule ($0.32 d^{\circ -1}$) an attempt of intrepretation can be proposed in terms of geotectonics.

Seismic waves from West Brittany in the Northwestern part of France or Mulhouse and Ugine in the East have been recorded mainly by stations in Normandy, Morvan and Central France (North of the Central Massif) and Vosges, that means essentially along the general trends of the Armoricain Massif.

Generated by the same earthquake in West Brittany, waves have also been recorded in Aquitain region, after having followed the trend of the South Armoricain accident.

On the contrary, Lg waves propagating from the Barcelona earthquake to French seismic stations have followed paths towards the North through the Pyrenées chain, the Massif Central, the Sillon Rhodanien, and consequently have travelled through inhomogeneous crustal structures characterized by thickness variations and deep faulting systems.

The propagation for the St Pourçain sur Sioule earthquake belongs to both of these two types of propagation. No interpretation is proposed here for this peculiar event.

Quality Factor Q

Using the filtering method previously described, we have computed Q as a fonction of frequency for each earthquake and for each crustal (Figure 11) and subcrustal phases (Figure 12).

./.

Assuming an attenuation factor due to geometrical spreading of 0.5, i.e. :

$$A \propto D^{-0.5} \quad e^{-KD}$$

with :

$$K = \frac{\pi f}{Q V}$$

has been computed as a fonction of frequency by least squares method, the velocity V being taken respectively as :

for	Pn	8.1 km/sec
	Sn	4.7 -
	Pg	6.0 -
	Lg	3.5 -

For each one of the four phases, Q increases with frequency from about 100 at 0.5 Hz to about 1 000 at 16 Hz. The dispersion for Pn and Sn waves is large in comparison to Pg and Lg waves. This anomaly, at least for the Q factor corresponding to Sn waves, could be due to poor Sn amplitude measurements in a sometimes large Pg coda.

For Pg and Lg waves, Q values show a general trend of converging for high frequencies for which amplitudes are less affected by crustal propagation anomalies than for low frequencies.

As was shown, the attenuation coefficient α due to geometrical spreading could be taken within a large range of values without affecting the fit to the data. Each value would result in one particular Q factor. Consequently, it is not realistic to compute absolute Q values but only a general trend can be given for each phase.

The mean slope of the Q versus frequency curves for Pg waves is around 0.8 - 0.9 and represents the least dispersed figure among the four seismic phases. Aki (1975) finds slopes of 0.6 - 0.8 on coda waves from Japanese earthquakes and Nuttli (1981) obtains values around 0.7 for Lg in the Novosibirsk region (USSR) Mitchell (1980) proposes 0.3 - 0.5 for Lg waves between periods of 1 sec to 40 sec.

The Q versus frequency curves for Sn waves fall into the two family groups : one family (W; Brittany and Oviedo) with low attenuation or high Q values ; one family (Mulhouse, Barcelo[illegible] d [illegible]ne) with higher attenuation or lower Q values. In the first case clear Sn data have been recorded ; on the contrary

weak and doubtfull Sn arrivals possibly mixed up with Pg wave coda are seen in the second case.
As was printed out formerly, the attenuation for the West Brittany earthquake appears to be the lowest one and gives high Q values for each of the four phases.

Conclusion

Using the seismic data from one homogeneous short period network installed in France, we have studied the propagation of regional crustal phases.
Global attenuation factors on broad band data, taking into account both geometrical spreading and anelastic attenuation are of the order of 2, for Pn and Sn waves. They are sligthly higher for Pg (2.3) and Lg (2.5) waves but the amplitude of these waves is largely dependent on the azimuth of propagation. It has been observed that Pg and Lg are strongly attenuated when propagating through the Sillon Rhodanien in France or the Ivrea zone in Italy, although Pn and Sn phases are clearly received for the same paths.

Lg / Pg ratios present, as a consequence, a large scatter between 1 and 10, with a mean trend around 3 to 4.

By using filtering techniques we were able to pursue the study further and evaluate anelastic attenuation and quality factor for different frequencies.
We found that the Lg attenuation factor is of the order of $0.2\ d^{\circ -1}$ at 1 Hz, a result to be compared with the values of $0.07 d^{\circ -1}$ (Eastern US), $0.15 d^{\circ -1}$ and $0.35 d^{\circ -1}$ (*respectively* Northern USSR and South of Caspian Sea) obtained by Nuttli. Apparently, the attenuation values for France and Northern USSR are similar.
Q factors, computed for each of the local phases, show a clear dependence on frequency, even if their absolute value cannot be confidently assessed.

One must nevertheless be carefull about interpretating this frequency dependence of Q. Laboratory studies on rock samples have not pointed out any variation of Q factor, except very recently, see Bonner and al (1981).

The apparent variations of Q obtained in this paper, might be a result of scattering effects or of different propagation paths associated with different frequencies.

FIGURE CAPTIONS

<u>Figure 1</u> 25 short period seismic stations (vertical component) which data are telemetered to a central station close to Paris where they are recorded on magtape (digital). Data are sampled at 50 samples/sec, with magnifications of 125 000 to 350 000 at 1 Hz.

The seismometer has a proper frequency of 1 Hz. The frequency band recorded on magnetic tape is 0.5 - 20 Hz.

<u>Figure 2</u> Seismometer frequency response in terms of magnification

1: seismometer alone

2: seismometer with amplifier and paper recorder

<u>Figure 3</u> Propagation paths from six earthquakes to French seismic stations

W B : West Brittany on the continental plateau

O : Oviedo in North West part of Spain

B : Barcelona in North East part of Spain

U : *Ugine in the northern Alps*

M : Mulhouse in the southern Rheingraben

<u>Figure 4</u> Broad band records in 3 seismic stations : LFF and LMR (Δ = 370 km); TCF (Δ = 500 km) for the Barcelona earthquake, magnifications (at 1 Hz) are 32 000 (LFF) and 125 000 (LMR, TCF). Tick marks every second. Pg and Lg phases are energetic when recorded at LFF (continental path); but no Pg and weak Lg are recorded at LMR at the same distance (oceanic path).

Pn and Sn are clear at both stations LFF and LMR; very weak at TCF.

<u>Figure 5</u> Peak to Peak amplitudes of Pg waves versus distance. 2.3 is the global attenuation cœfficient. Data are taken from broad band seismograms.

<u>Figure 6</u> Same figure caption for Lg phases.

<u>Figure 7</u> Lg/Pg ratio versus distance.

<u>Figure 8 and Figure 9</u> Digital filtering process is applied by using FIR technic (Finite Impulse Response) for different frequency bands. At the bottom of each figure is the broad band signal.

./.

<u>Figure 10</u> For three band passes, attenuation curves with different geometrical spreading coefficients α , are adjusted on data.

<u>Figure 11 and Figure 12</u> For Pn, Sn and Pg, Sg respectively quality factors are computed versus frequency for six earthquakes (when these phases exist).

A coefficient of geometrical spreading equal to $\alpha = 0.5$ has been taken for that purpose.

QUAKE	DATE	LAT.	LONG.	DEPTH	ML
W-BRITANNY	01/15/78	49.09N	5.49W	25Km	4.2
MULHOUSE	07/16/80	47.72N	7.29E	15Km	4.0
St POURCAIN	02/11/78	46.38N	3.19E	15Km	4.1
BARCELONA	12/14/80	41.67N	2.49E	SUP.	3.9
OVIEDO	01/16/79	43.06N	6.75W	SUP.	3.9
UGINE	12/02/80	45.78N	6.37E	SUP.	3.5

- Table I -

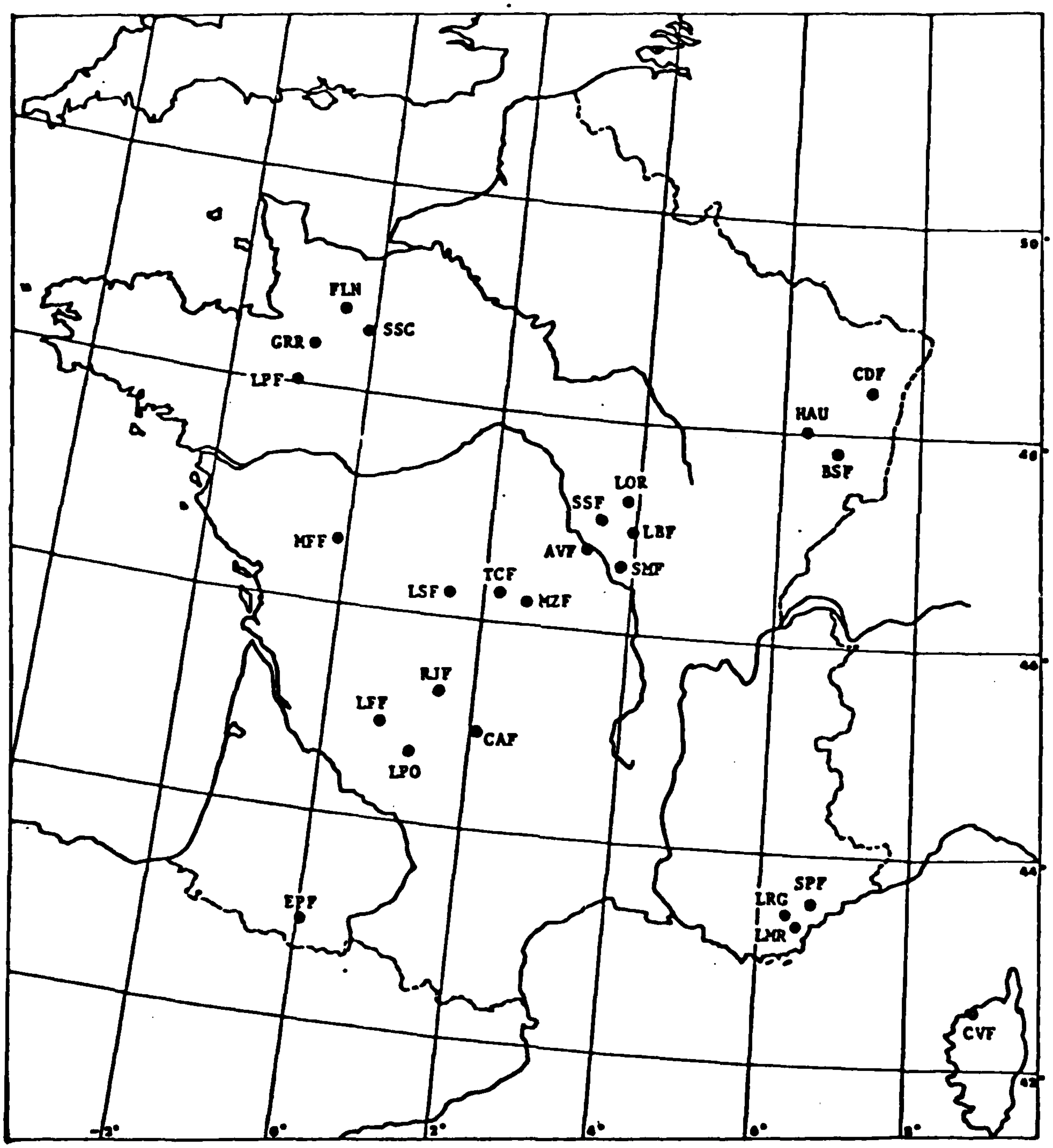
INELASTIC ATTENUATION FOR Lg (1Hz)

$$A = A_o * (D \sin D)^{-1/2} * EXP(-KD)$$

EARTHQUAKES	K (d^{o-1})
W-BRITANNY	0.16
OVIEDO	no Lg
BARCELONA	0.29
UGINE	0.09
MULHOUSE	0.15
St POURCAIN	0.32

- Table II -

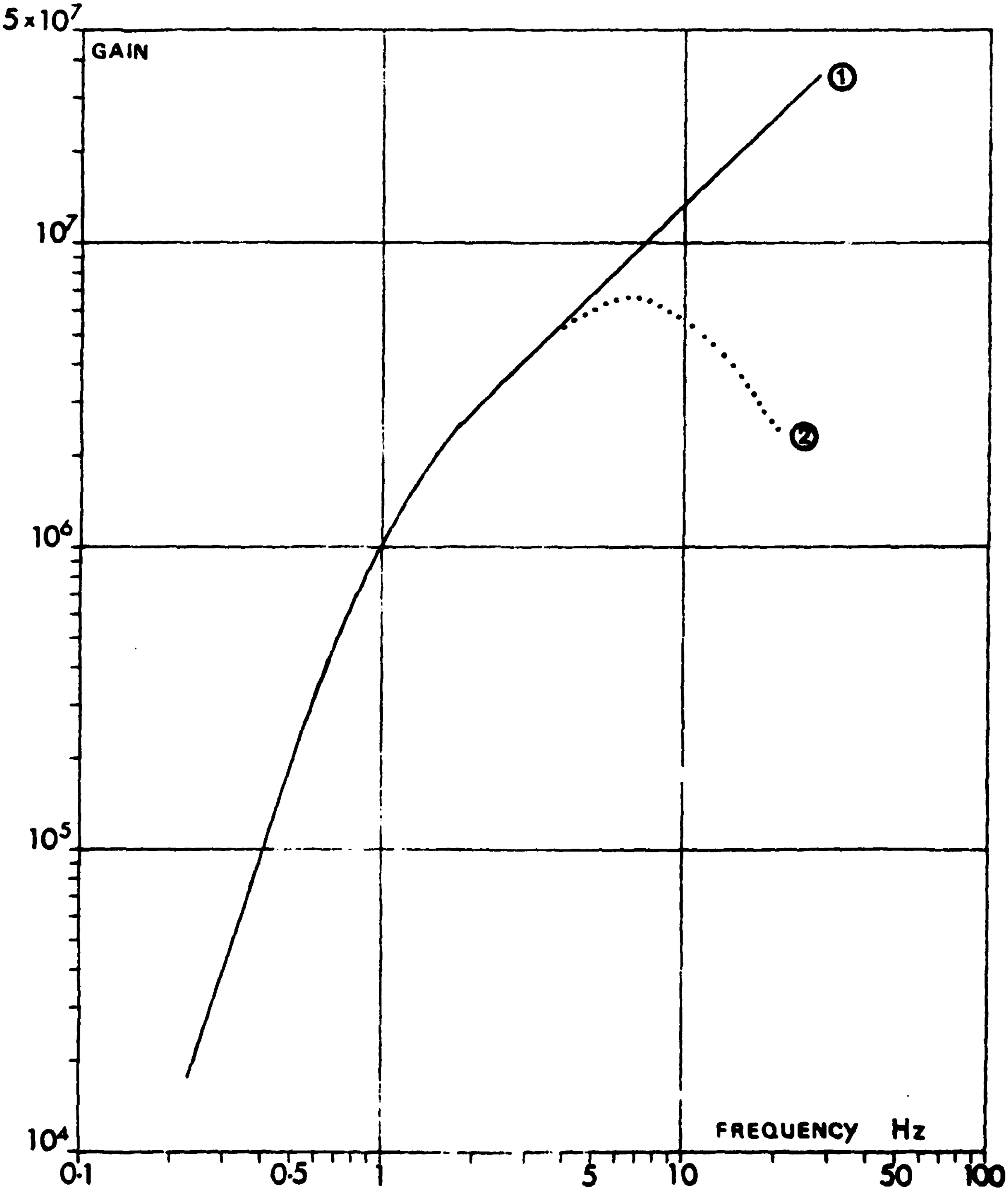
SEISMIC NETWORK OF L. D. G.



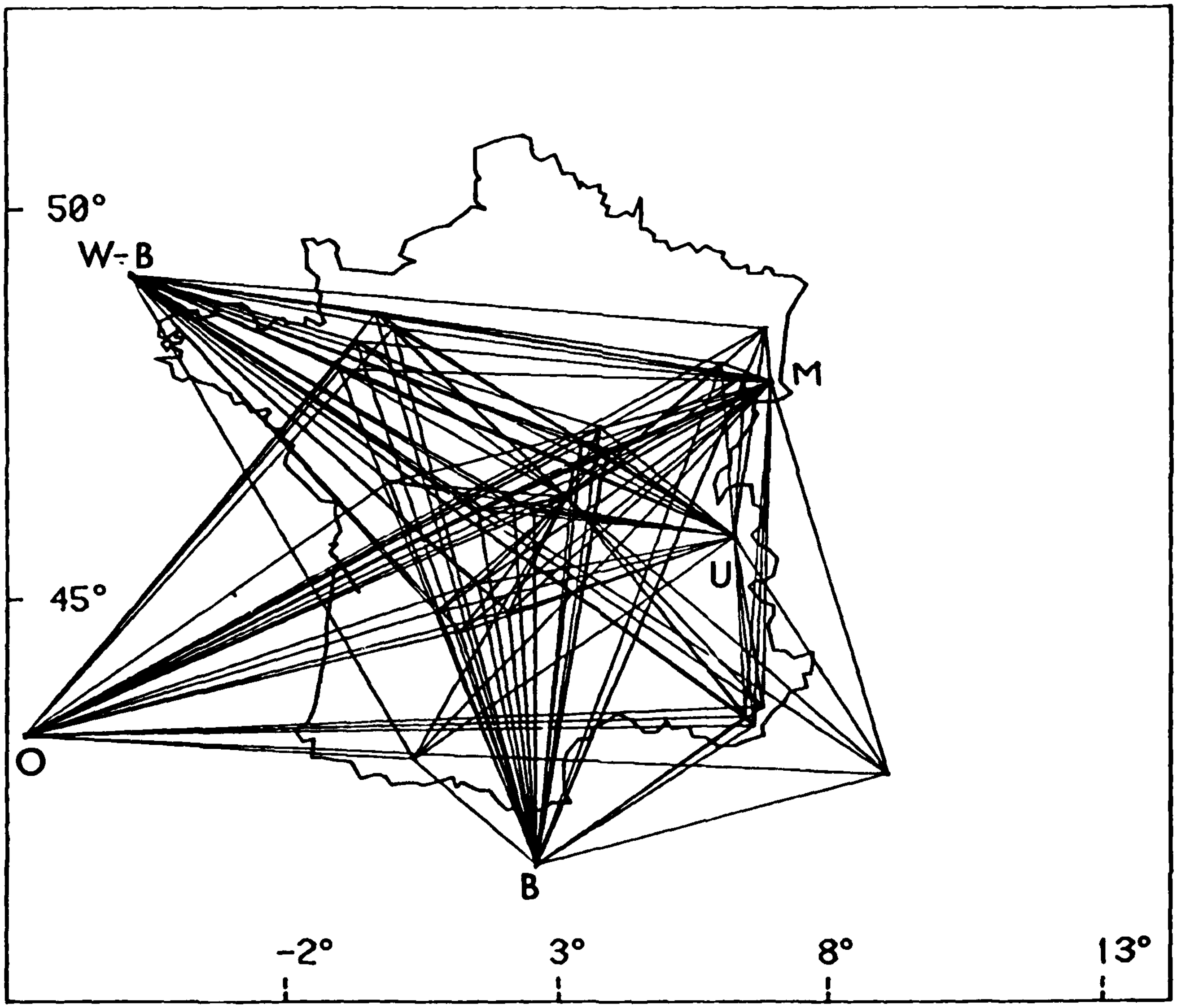
● Seismic stations

- Figure 1 -

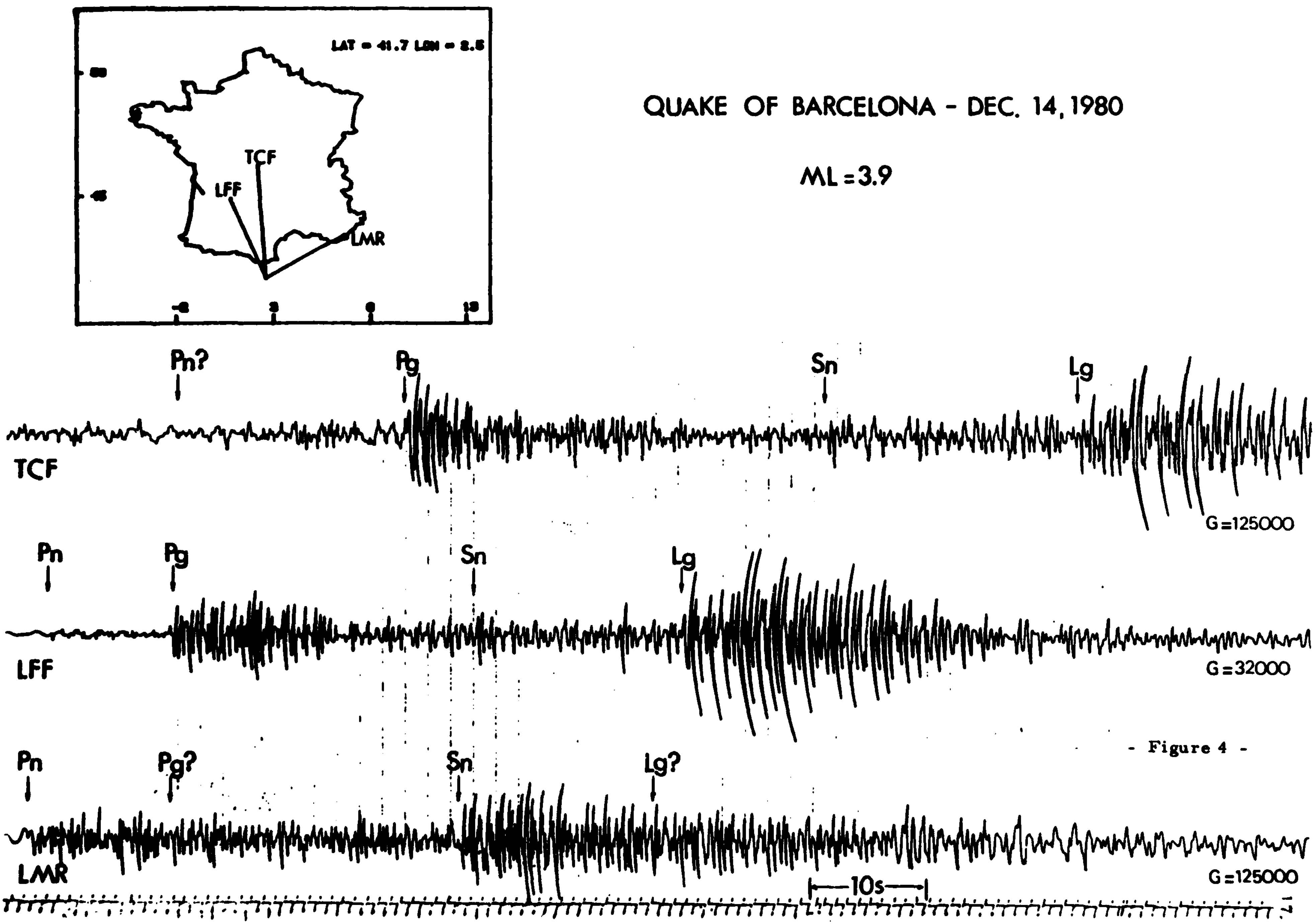
SHORT PERIOD SEISMOMETER - FREQUENCY RESPONSE



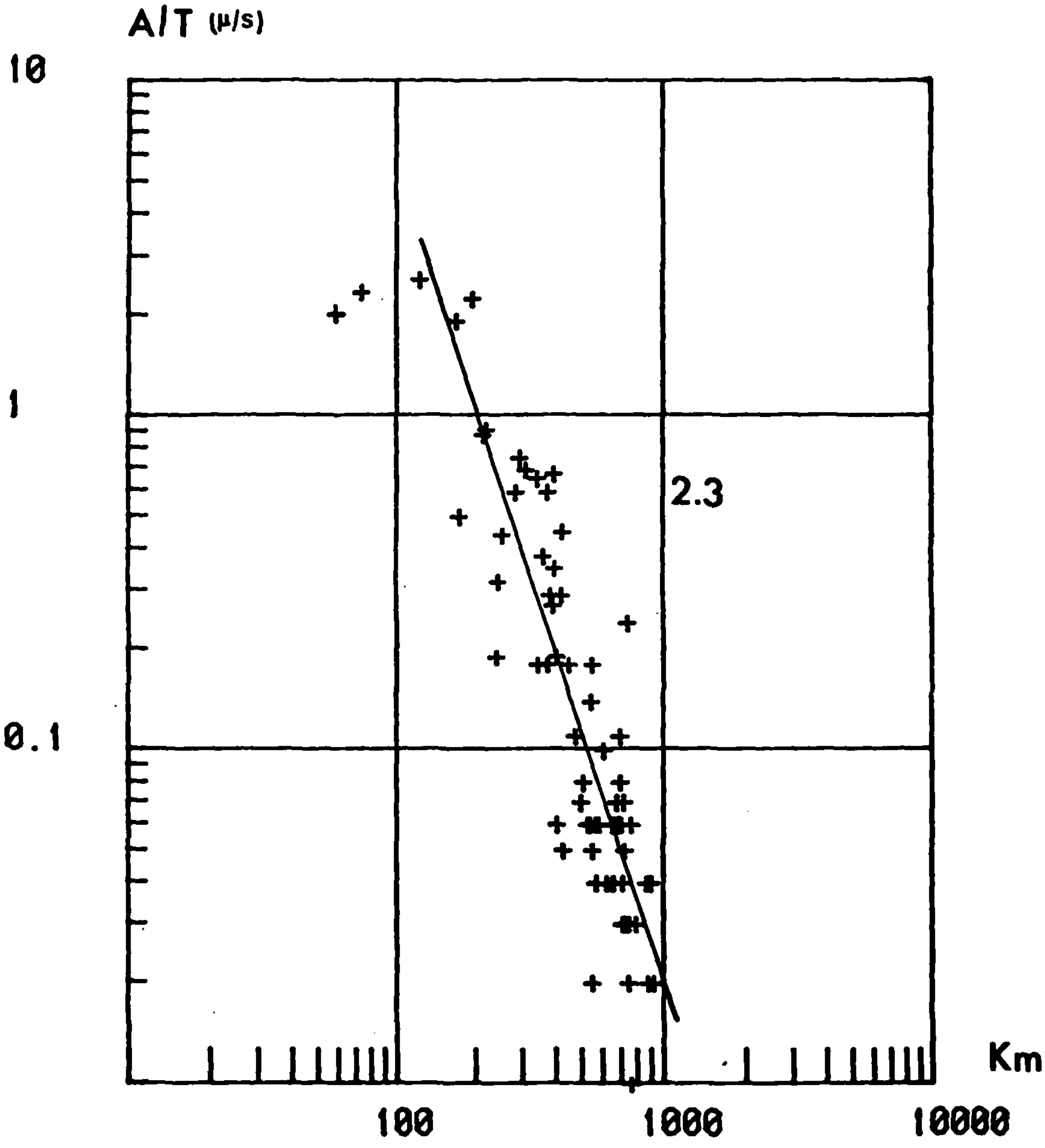
- Figure 2 -



- Figure 3 -

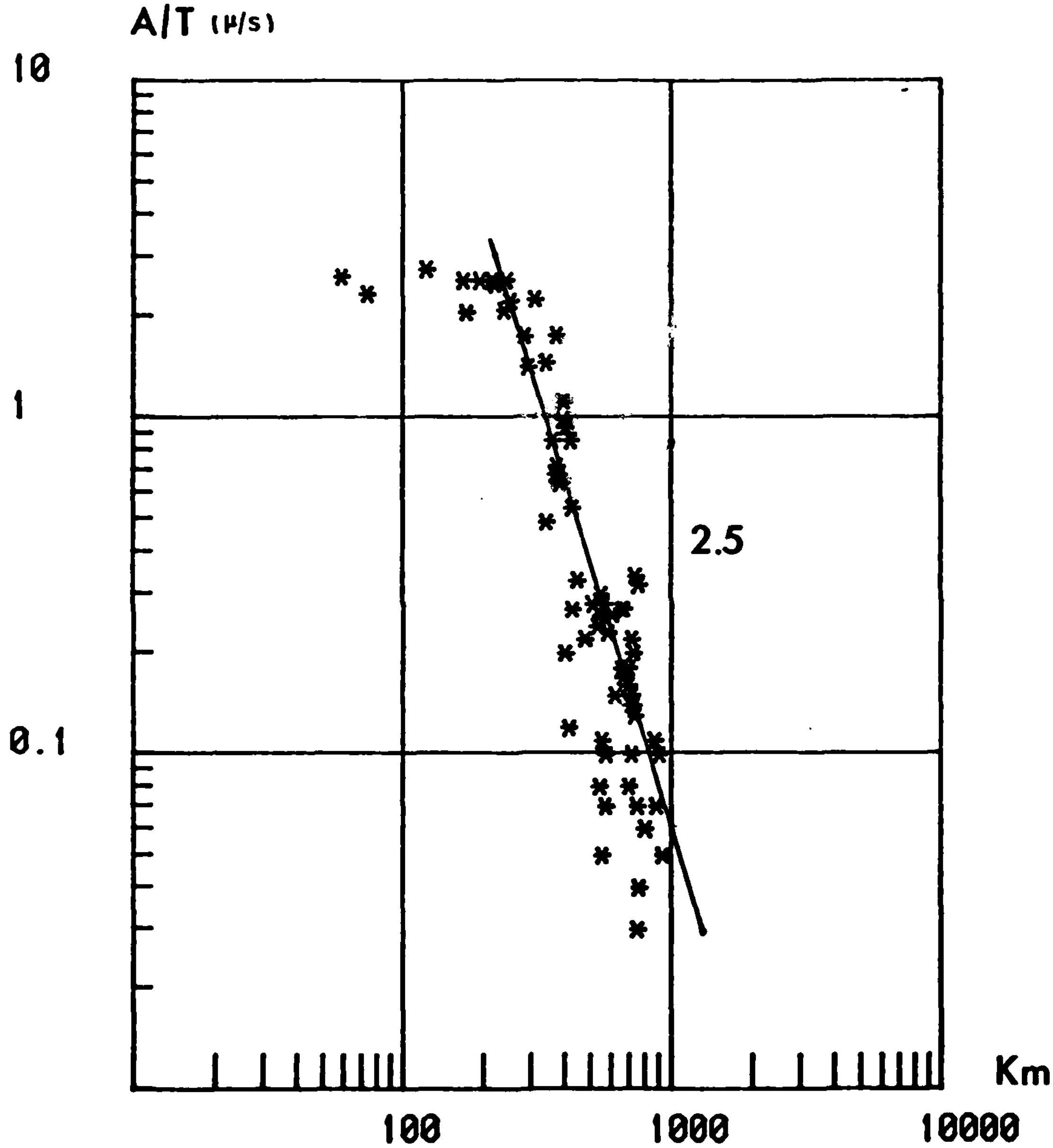

QUAKE OF BARCELONA - DEC. 14, 1980
ML = 3.9
LAT = 41.7 LON = 2.5
TCF
LFF
LMR
Pn?
Pg
Sn
Lg
G=125000
Pn
Pg
Sn
Lg
G=32000
Pn
Pg?
Sn
Lg?
G=125000
10s

- Figure 4 -



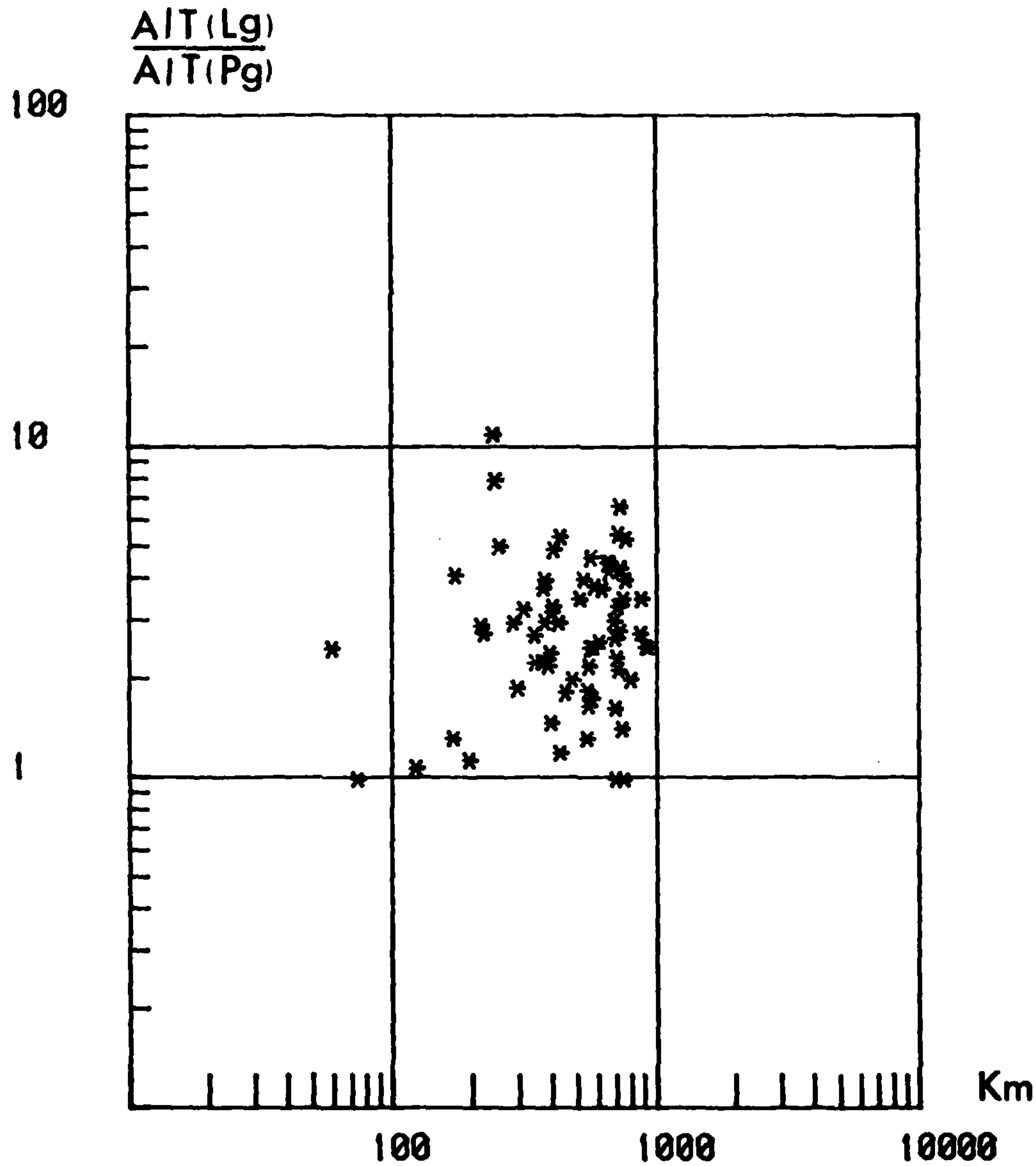
AMPLITUDE OF P_g VERSUS DISTANCE

- Figure 5 -



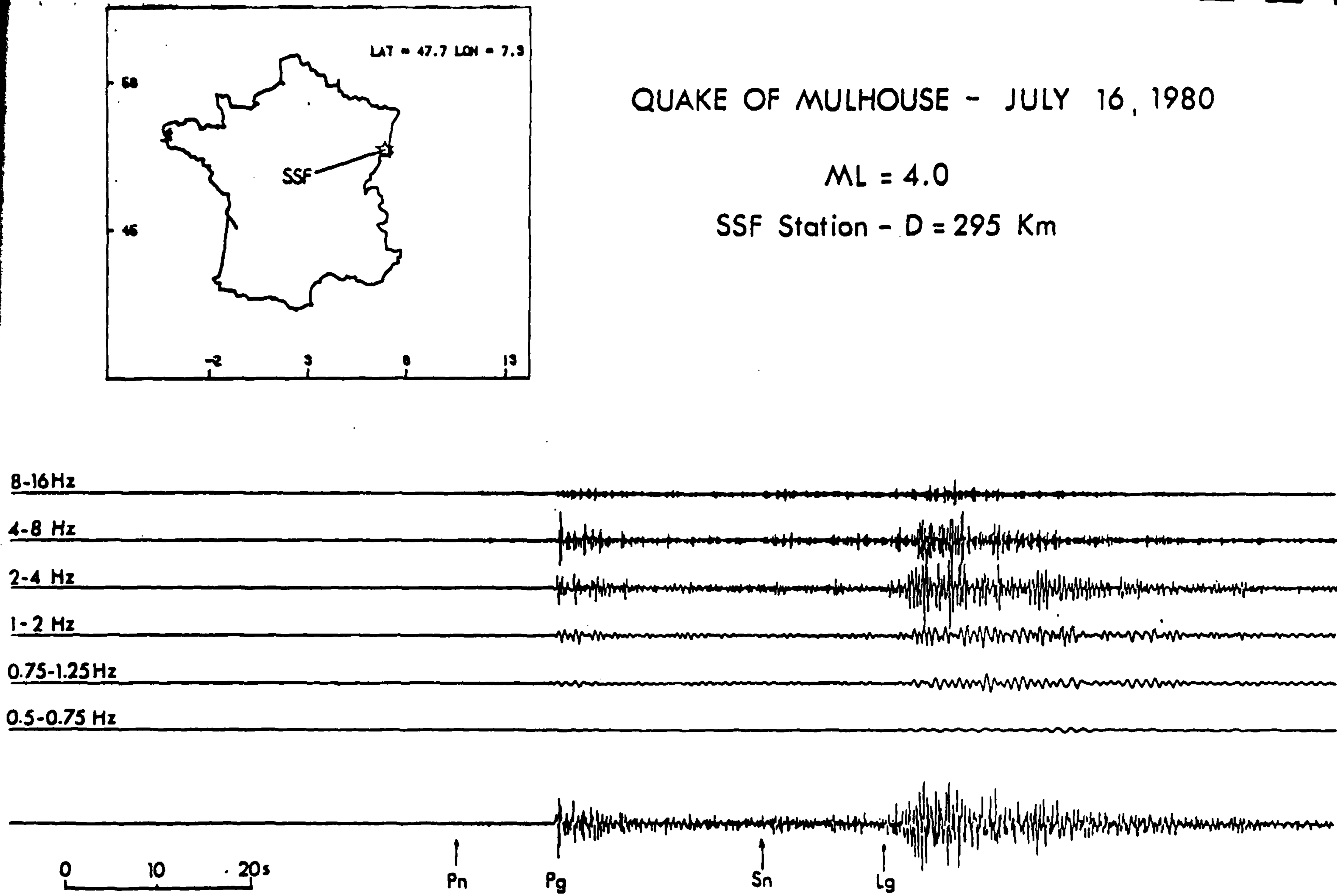
AMPLITUDE OF Lg VERSUS DISTANCE

- Figure 6 -

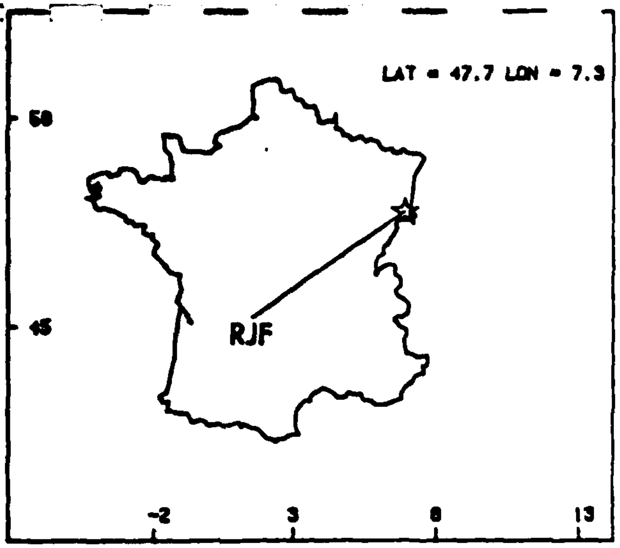


Lg/Pg VERSUS DISTANCE

- Figure 7 -


LAT = 47.7 LON = 7.3
50
46
-2
3
8
13
SSF
QUAKE OF MULHOUSE - JULY 16, 1980
ML = 4.0
SSF Station - D = 295 Km
8-16Hz
4-8 Hz
2-4 Hz
1-2 Hz
0.75-1.25Hz
0.5-0.75 Hz
0
10
20s
Pn
Pg
Sn
Lg

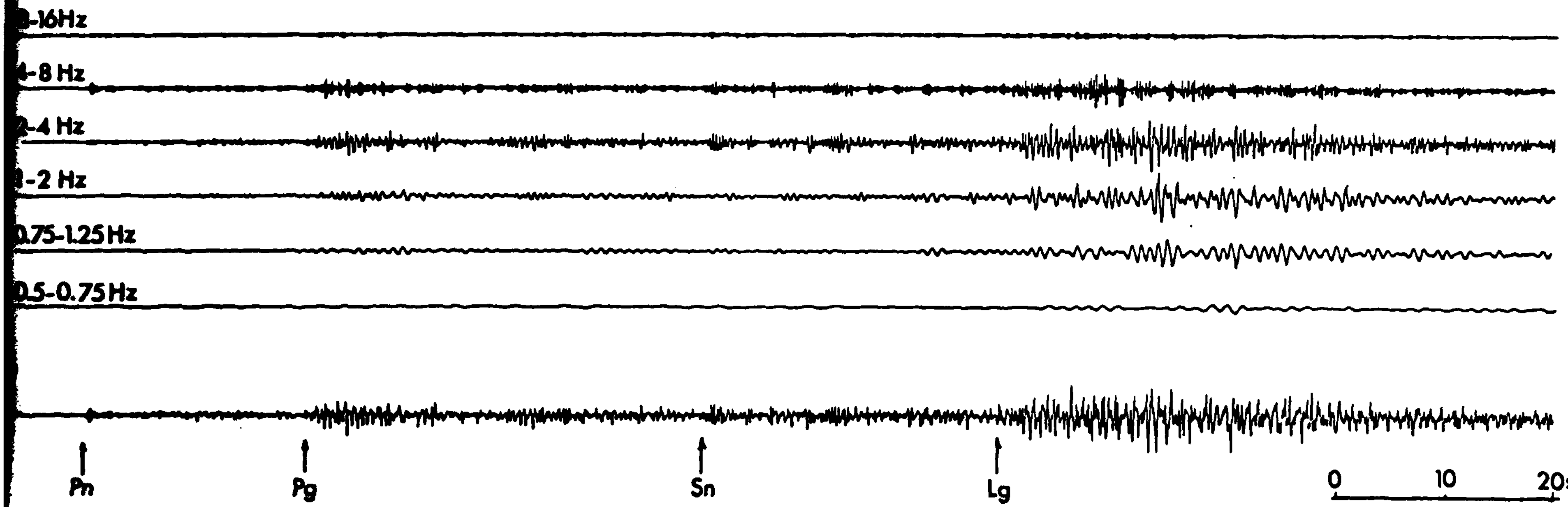
- Figure 8 -



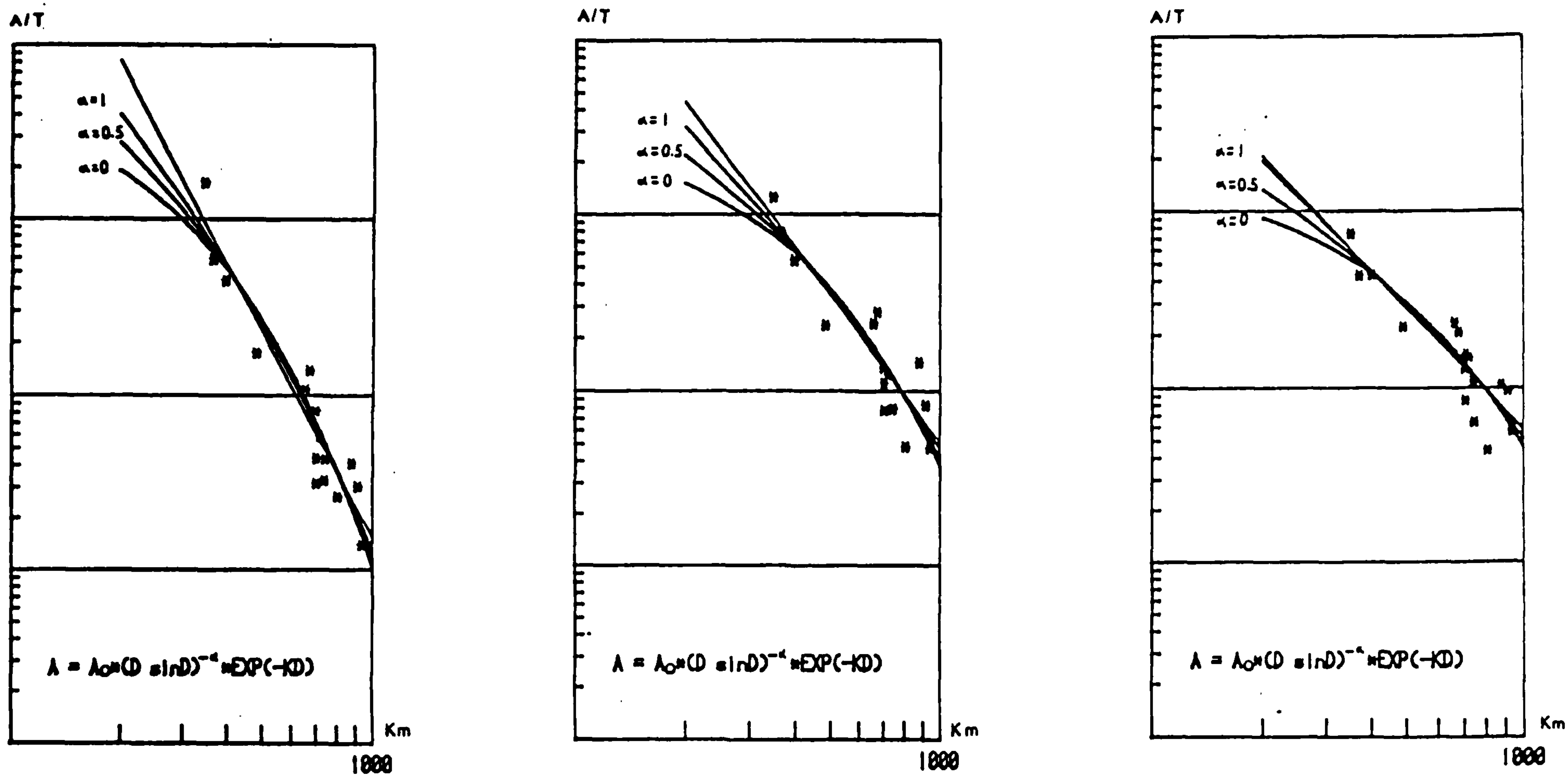
QUAKE OF MULHOUSE - JULY 16, 1980

ML = 4.0

RJF Station - D = 518 Km



- Figure 9 -



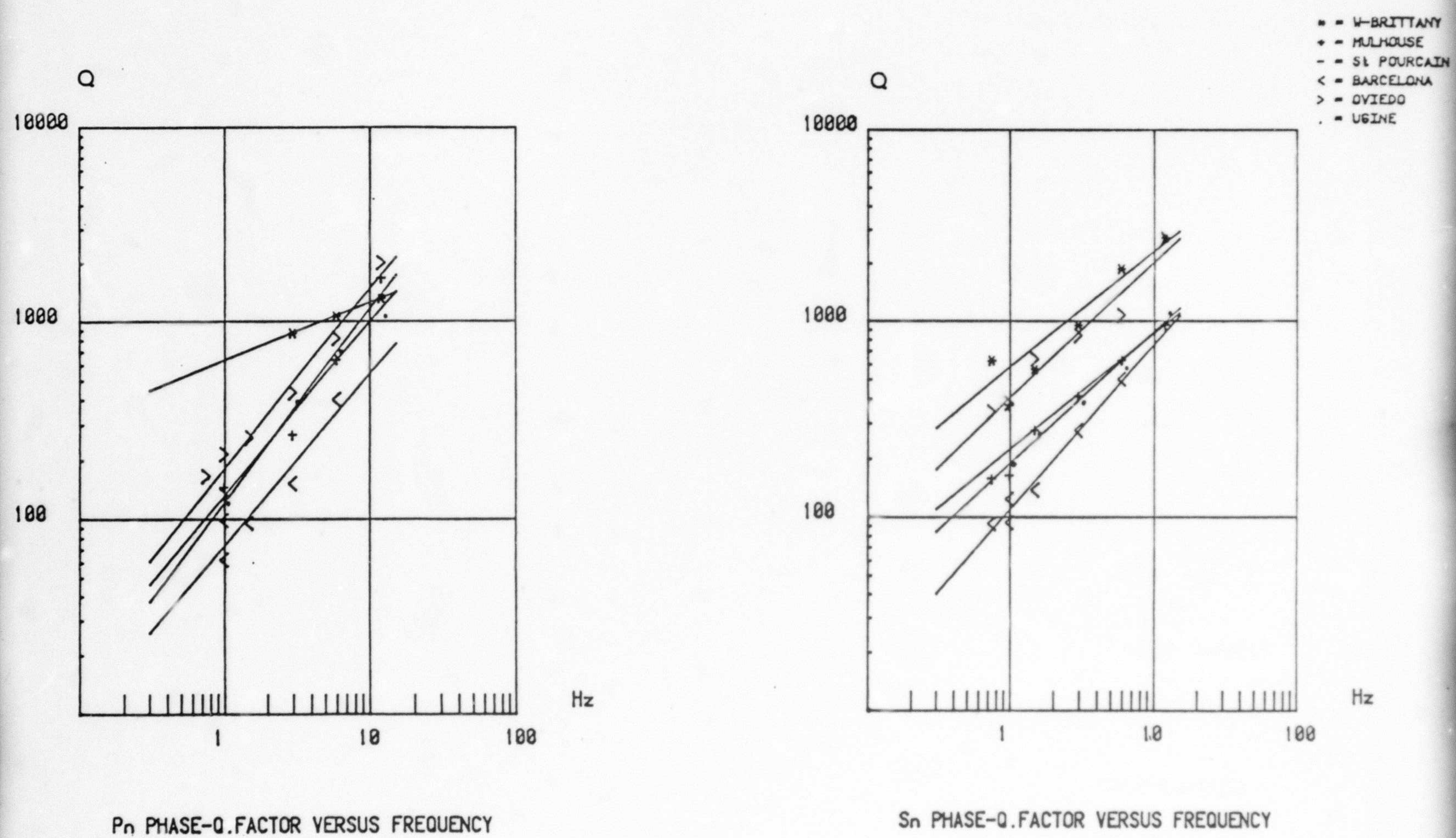
Lg PHASE 4 - 8 Hz

Lg PHASE 2 - 4 Hz

Lg PHASE 1 - 2 Hz

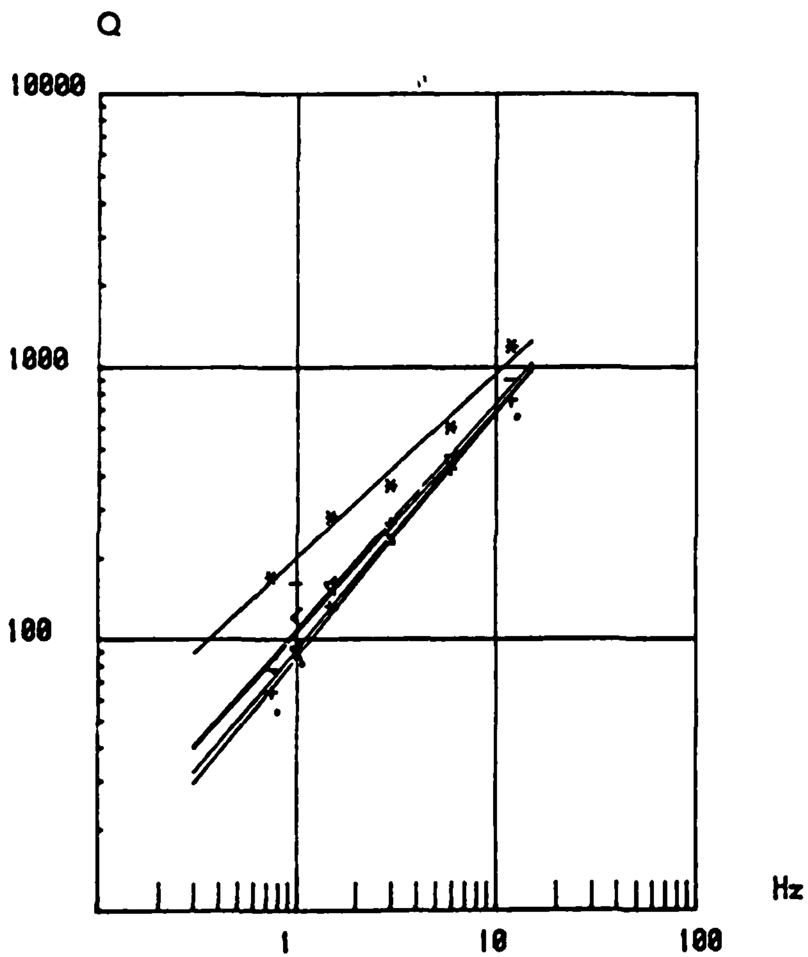
Lg ATTENUATION VERSUS DISTANCE FOR WEST BRITTANY EARTHQUAKE

- Figure 10 -

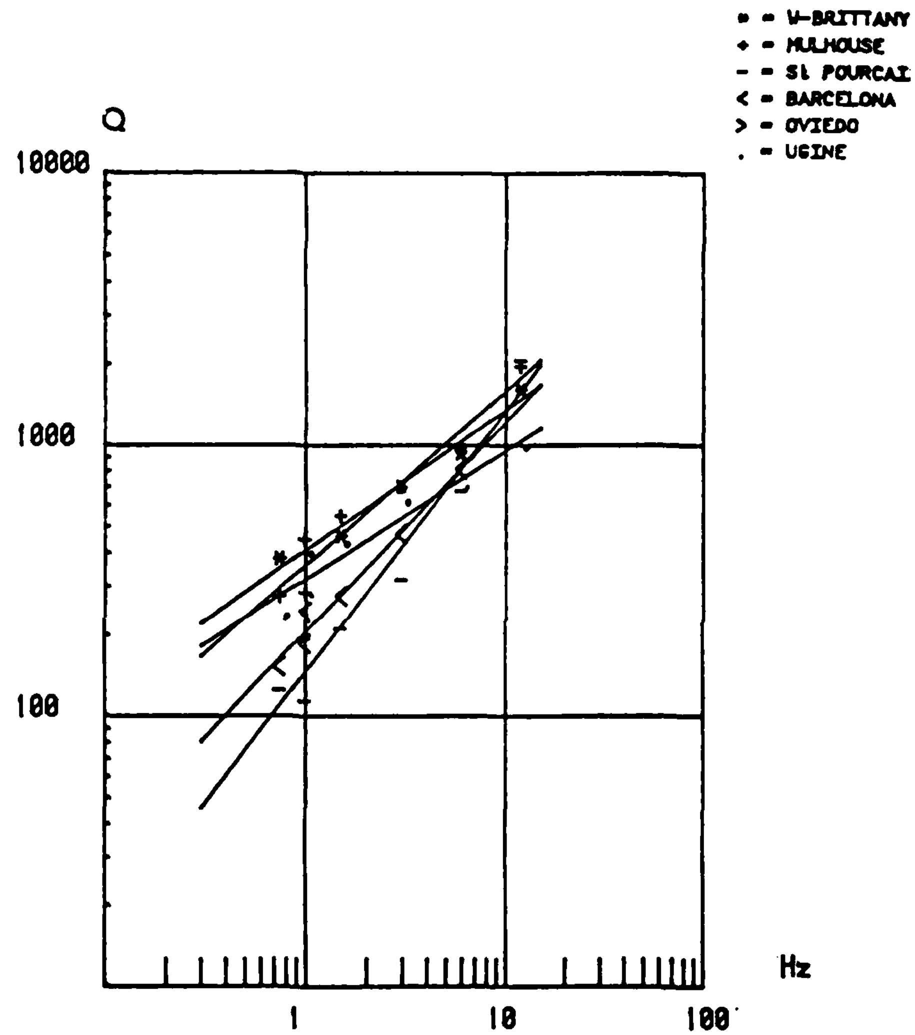


Q
10000
1000
100
1
10
100
Hz
Pn PHASE-Q.FACTOR VERSUS FREQUENCY
Q
10000
1000
100
1
10
100
Hz
Sn PHASE-Q.FACTOR VERSUS FREQUENCY
* = W-BRITTANY
+ = MULHOUSE
- = St POURCAIN
< = BARCELONA
> = OVIEDO
. = UGINE

- Figure 11 -



Pg PHASE-Q.FACTOR VERSUS FREQUENCY



Lg PHASE-Q.FACTOR VERSUS FREQUENCY

- Figure 12 -

Acknowledgments

This work was supported by the Advanced Research Projects Agency and was monitored by the Air Force Office of Scientific Research under grant n° 80 - 0082.

We are grateful to J. L. Plantet and A. Chaouch for their helpful comments on the manuscript.

REFERENCES

Aki, K. (1980). Scattering and attenuation of shear waves in the lithosphere, J. Geophys. Res. 85, 6496-6504.

Aki, K. and B. Chouet (1975). Origin of coda waves: Source, attenuation and scattering effects, J. Geophys. Res. 80, 3322-3342.

Bonner, B.P. and al. (1981). Laboratory observations of the anelastic response of rocks, DARPA, NMR, 81-03.

Der, Z.A. and al. (1980) A study of regional phases from earthquakes and explosions in western Russia, Bull. Seism. Soc. Am. 70, 851-872.

Ewing, M., W.S. Jardetzky and F. Press (1957). Elastic waves in layered media, Mc Graw-Hill, New York, 358.

Mitchell, B.J. (1980). Frequency dependence of shear wave internal friction in the continental crust of eastern north America, J. Geophys. Res. 5212-5218.

Nuttli, O.W. (1973). Seismic wave attenuation and magnitude relations for eastern North America, J. Geophys. Res. 78, 876-885.

Nuttli, O.W. (1981). On the attenuation of Lg waves in western and crustal Asia and their use as a discriminant between earthquakes and explosions, Bull. Seism. Soc. Am. 71, 249-261.

Nuttli, O.W. (1981). The Q structure of short period Lg waves in the western half of the USSR, DARPA, NMR, 81-03.

Pomeroy, P.W. (1978). Investigation of seismic wave propagation in western USSR, Rondout Associates, Inc., Stone Ridge, New York.

Richter, C.F. (1935). An instrumental earthquake scale, Bull. Seism. Soc. Am. 25, 1-32.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFOSR-TR- 81 -0784	2. GOVT ACCESSION NO. AD-A108501	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SEISMIC CRUSTAL AND SUBCRUSTAL PHASES PROPAGATION		5. TYPE OF REPORT & PERIOD COVERED ANNUAL ~~Final~~ Report 1 December 80 - 30 September 81
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. MECHLER, M. NICOLAS B. MASSINON, M. BOUCHON		8. CONTRACT OR GRANT NUMBER(s) AFOSR-80-0082
9. PERFORMING ORGANIZATION NAME AND ADDRESS RADIOMANA - Société Civile 27, rue Claude Bernard 75005 PARIS - FRANCE		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AREA & Work Unit Numbers PE: 61102F AO 3291-32
11. CONTROLLING OFFICE NAME AND ADDRESS AFOSR/NP Bolling AFB WASHINGTON DC 20332		12. REPORT DATE 30 October 1981
		13. NUMBER OF PAGES 27 (32)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release;
distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

SEISMOLOGY
CRUSTAL WAVES
SUB. CRUSTAL WAVES
PROPAGATION
ATTENUATION
FREQUENCY
EUROP

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study is to evaluate attenuation of local seismic phases in France.
Using a set of six earthquakes which occured in France or in its vicinity, the short period data recorded by a homogeneous seismic network (vertical component) have been used, within a range of epicenter to station paths of 1° to 10°.

(continued)

cont A

394823

DD FORM 1473

Abstract (continued)

Global attenuation versus distance has been determined for each phase Pn, Sn, Pg and Lg and the influence of frequency analysed. For Pn and Sn waves they are of the order of 2, and slightly higher for Pg (2.3) and Lg (2.5) waves. But the amplitude of these waves is largely dependent on the azimuth of propagation.

Lg/Pg ratios present a large scatter between 1 and 10 with a mean trend around 3 to 4.

1/0.7 deg

We found that the Lg anelastic factor is of the order of ~~0.2d°-1~~ at 1 Hz, a result to be compared with the values of ~~0.07d°-1~~ (Eastern US), ~~0.15d°-1~~ and ~~0.35d°-1~~ (respectively Northern USSR and South Caspian Sea)~~, obtained by Nuttli (1981)~~.

The quality factor, computed for each of these local phases, shows a clear dependence on frequency, increasing from some 100 at 1 Hz to some 1000 at 10 Hz probably due to scattering effects.

1/0.2 deg

1/0.15 deg

1/0.35 deg

A